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Efficient Performative Actions for E-Commerce Agents

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***Abstract* – The foundational features of multi-agent systems are communication and interaction with other agents. To achieve these features, agents have to transfer messages in the predefined format and semantics. The communication among these agents takes place with the help of ACL (Agent Communication Language). ACL is a predefined language for communication among agents that has been standardised by the FIPA (Foundation for Intelligent Physical Agent). FIPA-ACL defines different performatives for communication among the agents. These performatives are generic, and it becomes computationally expensive to use them for a specific domain like e-commerce. These performatives do not define the exact meaning of communication for any specific domain like e-commerce. In the present research, we introduced new performatives specifically for e-commerce domain. Our designed performatives are based on FIPA-ACL so that they can still support communication within diverse agent platforms. The proposed performatives are helpful in modelling e-commerce negotiation protocol applications using the paradigm of multi-agent systems for efficient communication. For exact semantic interpretation of the proposed performatives, we also performed formal modelling of these performatives using BNF. The primary objective of our research was to provide the negotiation facility to agents, working in an e-commerce domain, in a succinct way to reduce the number of negotiation messages, time consumption and network overhead on the platform. We used an e-commerce based bidding case study among agents to demonstrate the efficiency of our approach. The results showed that there was a lot of reduction in total time required for the bidding process.**

***Keywords* – Cooperative communication, electronic commerce, formal languages, multi-agent systems.**

I. Introduction

Nowadays electronic commerce (e-commerce) is getting more and more popular as the use of the Internet goes on increasing. The number of buyers and sellers on the Internet is growing on a fast pace. Sellers get familiar with market trends on the Internet and plan their selling policies to entice buyers through the Internet. All of this has greatly affected the overall business online. E-commerce is bringing new changes in the traditional business methods. In this way the approaches buyers and sellers use to interact and communicate with one another have been modernised. It poses and presents a huge variety of goods and articles to the interested customers. In agent-based e-commerce, it is not necessary for sellers and buyers to have a direct communication link at the moment, instead the important thing is that how these agents communicate. However, it is imperative to create a usual dialogue for sale and purchase activity of a given product automatically and intelligently [1]. E-commerce negotiations performed through agent communication is an important domain of the agent theory and technology [2], [3]. The collaboration among agents is managed by the 'negotiation protocols' that are a predefined set of instructions. Such protocols permit valid and legal applicants, define mediation rules and regulations and subsequent actions that effect mediation. Mediation entities are the series of concerns on which settlement must be done. In e-commerce, negotiation is extremely important as it decides controversies between the objects that have different objectives. Different successful studies on the protocols and schemes in the area of mediation reveal that it requires a long period of time to implement such protocols successfully [2]. Maximum research on the negotiation of agents is at the experimental phase that owes to the absence of certain cohesive expertise standards, which makes it very difficult to comprehend. Almost all researchers have presented their literature in their own way [4]. It is quite difficult for negotiating agents with dissimilar communication protocols to negotiate with one other, for the reason that they do not have public and universal message conversation arrangement. In an attempt to resolve the above-mentioned problem, some organisations have formulated certain agreed rules. Currently, there are two core technical circumstances that follow the excellence of the agent communication layout. First is Knowledge Query and Manipulation Language (KQML), while the other is Foundation for Intelligent Physical Agents (FIPA). Our work is solely based on the FIPA-ACL because of its widespread usage and better tool support. Unfortunately, performatives defined by FIPA-ACL are generic in nature and they are not directly applicable to any particular domain, i.e., e-commerce. For instance, "confirm" speech act to assist negotiation is defined by FIPA-ACL, but in practice the circumstances of negotiation are quite hard and of different pattern in e-commerce. Negotiation needs not only "confirm", but also "confirm about selling the product", "confirm about purchasing the product",

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and other similar speech acts to carry out the negotiation process effectively. Additionally, many FIPA-ACL operations are distinctive, so it becomes challenging for the agents to communicate effectively in such scenarios. The main objective of the proposed research is to formulate a way to establish a clear interface for agents in an automated negotiation by using existing FIPA-ACL performatives for e-commerce domain, thus providing a mechanism for the agents to communicate without any ambiguity when using generic performatives. We formulated new performatives for the negotiation among agents in e-commerce by using FIPA-ACL performatives. It will reduce the number of negotiation messages, time consumption and network overhead on the platform and enable faster communication.

The rest of the paper is structured as follows. In Section II, we elaborate the related works highlighting the limitations of the current research relative to the proposed approach. In Section III, we define the proposed FIPA performatives for the negotiation among agents in e-commerce domain. Section IV demonstrates the efficiency of the proposed performatives in e-commerce domain. Section V concludes the paper and provides future areas of research.

II. Related Works

A lot of work has been done in the past on the negotiation in multi-agent systems. However, according to our knowledge no work has been done that optimises the negotiation process with respect to any specific domain like e-commerce. The study of automated negotiation for multi-agent systems associated with agent negotiation rules, negotiation entities and the prototypes of decision-making has already been examined [3]. Model of negotiation has been developed that permits the customer to inquire about the features of product, including the value of the product [4]. An intelligent has been designed for a negotiation mechanism to collaborate among agents. It has been explained how compatible policies can be planned to prevent deadlocks by enhancing the decision-making ability of agent and the coordinator behaviour [5]. A protocol that allows for various alarms linked to the awareness of semantic and technical expressions has been presented [6]. A multi-agent based two-way negotiation for the Hotel Reservation (MAB-TNHR) with three kinds of agents has been developed. Agents express their interests of persons and gathering of the data. They presented a case study on the usage of rules applied to explain the execution of MAB-TNHR [7]. A systematic literature review of Multi-Agent System (MAS) negotiation protocols is also discussed in [8] providing an inclusive summary of the pros and cons regarding the rules examined that are applied at the time of development. A two-phase negotiation agenda has been proposed in [9] and the authors considered a make-to-order fashion supply chain, where creators and brokers are supportive on time-limit and price. Their objective was to catch the best result for settlement in negotiation problems like production cost and mutual benefit. A simple neural model called CommNet is explored in [10] that practices non-stop communication for totally supportive jobs and contains a number of agents and determines the learned communication among them. A dialogical method for post negotiation, where agents can communicate and recognise destructions with stability and conventional rules has been presented [11]. A negotiation protocol has been implemented that is able to retain the buying company and communication of the dealer on the actual obligations of numerous goods concurrently [12]. A policy of bidding schemes, which aims at estimating the bid amounts for customers at a specific instant established on their bidding activities and their estimation of an auctioned item has been presented in [13]. A buyer collective negotiation (BCN) model to make wishes of the customers and permit the mediation between customers and retailers sponsoring a deal of retailers is discussed in [14]. A multi-strategy negotiating agent system is proposed that explains the conceptual model of an agent and plans its theoretical design, including contract-net protocol [15]. A model for B2C e-commerce for automatic negotiation between agents has been discussed. Their approach organises the agents to perform online sale and purchase negotiation and rapidly reply to the customers [16]. An agent-based simulation PIRASA has been demonstrated, in which customer or supplier principles are applied by agents. They showed how an intelligent agent can be enabled to trade things in e-commerce market [17]. A framework for the negotiation of agents by using constraint-based techniques is discussed. Different agents work as the representative of a user. When one cycle of negotiation gets completed, it informs the coordinating agent. Subsequently, a coordinating agent gives new guidelines [18]. Negoisst, a negotiation support system for electronic communication that implemented theories of communication, information system is discussed in [19]. Protocols for negotiation, along with policies for smart agent negotiation in e-business to alleviate the human work have been presented in [20]. A method for multi-issue negotiation has been discussed in [21] to keep away from a deadlock, in which both agents are averse to allow or decline in order to reveal more data in an alternating-offer pattern when the data of both agents is fully private. Overview on the diversity of agent application in commerce is discussed in [22] where agents have impact on social matters having ability to use in smart e-commerce systems. A mobile-agent based framework of one-to-many bilateral e-trade negotiation is proposed in [23] that handles the risk of losing top service deals and maximises customer's deals with some constraints. A multi-agent e-commerce system is designed in [24] by using fuzzy logic based on JADE framework to assist the consumers in defining their choices correctly about a product. A tool called 'General Environment for Negotiation with Intelligent Multi-purpose Usage Simulation' (GENIUS) for automated negotiation simulation of agents has been developed in [25]. Four distinct platforms – JADE, Concordia, voyager and aglet – for the agent negotiation in e-commerce domain is discussed in [26]. A consequence of search on e-commerce is discussed by means of the recommended technology. The aspects occupied for the search are common benefits of the users, browsing activities and present styles of sales [27]. A mathematical model is formed by using negotiation strategies for the negotiation of agents, which implements in multi-issue negotiation environments. Their

work presents a comparison of some negotiation methods and proposes an automated negotiation system by using linear programming and matching based systems [28]. A model is described for the agents that assists them to complete a successful deal in e-commerce by assuming the aim of e-commerce domain and the goal of the agents [29]. A computational model is described for the e-commerce negotiation that covers the negotiation protocols, issues, strategies and behaviour configuration mechanism [30]. Researchers have presented important modules of automated negotiation, analysis and match machine learning methods in automated negotiation [31]. A system has been developed for the agent negotiation by using JADE framework with declarative negotiation strategies [32]. A study of the scenarios for applying software agents in negotiations with the human fellows has been presented. The authors examine the attraction between agent's actions and task complexity [33]. In [34], the authors describe agents' negotiation by using JADE framework in e-commerce environment and consider how agents change their protocol and strategies by using dynamic loading of negotiation modules [34]. A model of stable multilateral automated negotiation based on JADE framework that helps the buyers and sellers to negotiate in e-commerce has been presented in [35]. A real-time application based on FIPA agent communication language and data distribution service (DDS) standards has been developed in [36]. It has been argued that formal modelling of agent communication is necessary to ensure their correct functioning in real-time environment [37]–[38]. Guidelines on the contemporary e-commerce strategy in supply chain management and insurance policy market has been presented in [39]–[41].

III. The Proposed Performatives for E-Commerce Agent Negotiation

In this section, we elaborate the proposed performatives for negotiation along the agents based on standard FIPA performatives. We have defined a nonterminal keyword 'MStructure' to reduce the size of BNF for all performatives, e.g., in the BNF given below without MStrucrture the same contents would have to be repeated three times.

A. Purchase

This performative is the combination of three FIPA performatives, i.e., **'request'**, **'inform'** and **'query-if'**. Agent uses all these performatives at the same time to accomplish a single task. Firstly, the agent requests for a product using **'request'**. It then notifies the information of the product via **'inform'**. Lastly, it enquires about the availability of the product by using **'query-if'**. The formal modelling of the purchase performative by means of BNF is given below.

Purchase ⟶ request + inform+ query-if
MStructure ⟶ sender + receiver + content + address + language + ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
request ⟶ MStructure
inform ⟶ MStructure
query-if ⟶ MStructure

Purchase
request Agent requests for a product with '**request'** FIPA performative **inform** Agent notifies the information of the product **query-if** Agent queries about the availability of the product by using '**query-if**' FIPA performative

1. Contents of Purchase by using FIPA Performatives

Content-1
(REQUEST
:sender Customer Agent
:receiver Seller Agent
:content Agent requests for a product
:language ------
:ontology ------
)

Content-2
(INFORM
:sender Customer Agent
:receiver Seller Agent
:content Agent provides information of desired product
:language --------
:ontology --------
)

Content-3
(QUERY-IF
:sender Customer Agent
:receiver Seller Agent
:content Agent asks about the availability of a product
:language --------
:ontology --------
)

2. Contents of Purchase by Using Purchase Performative

Content-1
(PURCHASE
:sender Customer Agent
:receiver Seller Agent
:content Agent requests for a product. It tells about the information of the product and queries about the availability of the product
:language --------
:ontology --------
)

B. DealNegotiate

This performative is the conjugation of **'agree'** and **'inform'** FIPA performatives. Agent accepts the request and gives positive response of the deal by using **'agree'**. It informs about the dealing parameters of the product by using **'inform'**. The formal modelling of DealNegotiate performative by means of BNF is given below.

DealNegotiate ⟶ agree + inform
MStructure ⟶ sender + receiver + content + address + language + ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
agree ⟶ MStructure
inform ⟶ MStructure

DealNegotiate
agree Agent accepts the request and gives good response to the deal with **'agree'** FIPA performative **inform** Agent informs about the dealing constraints of the product by using '**inform**' FIPA performative

1. Contents of 'DealNegotiate' by Using FIPA Performatives

Content-1
(AGREE
:sender Seller Agent
:receiver Buyer Agent
:content Agent accepts the request for dealing a product
:language ———
:ontology ———
)

Content-2
(INFORM
:sender Seller Agent
:receiver Buyer Agent
:content Agent informs about the information of the dealing product
:language ———
:ontology ———
)

2. Contents of 'DealNegotiate' Performatives

Content-1
(DEALNEGOTIATE
:Sender Seller Agent
:Receiver Buyer Agent
:Content Agent accepts the request and it gives the information of the product under deal
:Language ———
:Ontology ———
)

C. PactApprovalNegotiation

This performative is coined by using **'agree'** and **'query-if'** FIPA performatives. With these performatives, agent agrees to a deal of the product with **'agree'** and enquires about the dealing receipt of the product via **'query-if'**. The formal modelling of the PactApprovalNegotiation performative by means of BNF is given below.

PactApprovalNegotiation ⟶ agree + query-if
MStructure ⟶ sender + receiver + content + address + language + ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
agree ⟶ MStructure
query-if ⟶ MStructure

PactApprovalNegotiation
agree Agent agrees on the deal with **'agree'** FIPA performative **query-if** Agent enquires about the dealing receipt of the product by using **'query-if'** FIPA performative

1. Contents of 'PactApprovalNegotiation' by Using FIPA Performatives

Content-1
(AGREE
:sender Buyer Agent
:receiver Seller Agent
:content Agent agrees on the deal of the product
:language ———
:ontology ———
)

Content-2
(QUERY-IF
:sender Buyer Agent
:receiver Seller Agent
:content Agent demands for the receipt of the product
:language ———
:ontology ———
)

2. Contents of 'PactApprovalNegotiation' Performative

Content-1
(PACTAPPROVALNEGOTIATION
:sender Buyer Agent
:receiver Seller Agent
:content Agent agrees on the deal of the product from seller agent and it demands for the receipt of the dealing product
:language ———
:ontology ———
)

D.SaleProduct

This performative is a combination of **'request'** and **'inform'** FIPA performatives. It is used as a request to sale a particular product by means of **'request'** and provides all the specifications and characteristics of the product. The formal modelling of the SaleProduct performative by means of BNF is given below.

SaleProduct ⟶ request + inform
MStructure ⟶ sender + receiver + content + address + language + ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
request ⟶ MStructure
inform ⟶ MStructure

SaleProduct
request It is used for the request to sale its product by means of **'request'** FIPA performative **inform** It provides all specifications and characteristics of the product with **'inform'** FIPA performative

1. Contents of 'SaleProduct' by Using FIPA Performatives

Content-1
(REQUEST
:sender Buyer Agent
:receiver Seller Agent
:content Agent requests for selling a product
:language ———
:ontology ———
)

Content-2
(INFORM
:sender Buyer Agent
:receiver Seller Agent
:content Agent provides all information of selling product
:language ———
:ontology ———
)

2. Contents of 'SaleProduct' Performatives

Content-1
(SALEPRODUCT
:sender Buyer Agent
:receiver Seller Agent
:content Agent requests for selling a product and gives all information of product
:language ———
:ontology ———
)

E. PermissionNegotiation

This performative is made up of **'inform'** and **'query-if'** FIPA performative. Agent informs about the deal with **'inform'** and it asks about the interest in the deal by using **'query-if'**. The formal modelling of the PermissionNegotiation performative by means of BNF is given below.

PermissionNegotiation ⟶ inform+ query-if
MStructure ⟶ sender + receiver + content + address + language +ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
inform ⟶ MStructure
query-if ⟶ MStructure

PermissionNegotiation
inform Agent provides information of the deal by using **'inform'** FIPA performative **query-if** Agent asks about the interest in the deal by using **'query-if'** FIPA performative

1. Contents of 'PermissionNegotiation' by Using FIPA Performatives

Content-1
(INFORM
:sender Seller Agent
:receiver Buyer Agent
:content Agent sends the information of the deal
:language ———
:ontology ———
)

Content-2
(QUERY-IF
:sender Seller Agent
:receiver Buyer Agent
:content Agent asks about the interest in the deal
:language ———
:ontology ———
)

2. Contents of 'PermissionNegotiation' Performative

Content-1
(PERMISSIONNEGOTIATIION
:sender Seller Agent
:receiver Buyer Agent
:content Agent informs regarding the deal of the product and enquires about the interest in the deal
:language ———
:ontology ———
)

F. Bid

This performative is a combination of three FIPA performatives, i.e., **'request'**, **'inform'** and **'request-when'** performatives. Agent uses these performatives in a sequence for biding purpose. Firstly, agent initialises the activity by putting a request for the biding of the product using **'request'**. Then it provides all the specifications and characteristics of the product via **'inform'**. It sets its minimum price goal and expects maximum profit from its product and tells the other agent that when deal of the product is complete then inform it by using **'request-when'**. The formal modelling of bid performative by means of BNF is given below.

Bid ⟶ request + inform+ request-when
MStructure ⟶ sender + receiver + content + address + language + ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
request ⟶ MStructure
inform ⟶ MStructure
request-when ⟶ MStructure

Bid

request
Agent requests for the biding of the product by using '**request**' FIPA performative
inform
Provides all specifications and characteristics of the product via '**inform'** FIPA performative.
request-when
When deal of product becomes complete then inform me.

1. Contents of Bid by Using FIPA Performatives

Content-1
(REQUEST
:sender Buyer Agent
:receiver Seller Agent
:content Agent requests for bidding of a product
:language ———
:ontology ———
)

Content-2
(INFORM
:sender Buyer Agent
:receiver Seller Agent
:content Agent provides all information of the product
:language ———
:ontology ———
)

Content-3
(REQUEST-WHEN
:sender Buyer Agent
:receiver Seller Agent
:content Agent sends a request to inform when the bid is done
:language ———
:ontology ———
)

2. Contents of 'Bid' Performative

Content-1
(BID
:sender Buyer Agent
:receiver Seller Agent
:content Agent requests for bidding of its product. It gives all information on the product and wants to maximise profit
:language ———
:ontology ———
)

G. Broadcast

This performative is produced by combining **'CFP'** and **'inform'** FIPA performatives. Agent sends proposal by using **'CFP'** and then provides all the specifications and characteristics of the product by using **'inform'**. The formal modelling of the Broadcast performative by means of BNF is given below.

Broadcast ⟶ CFP + inform
MStructure ⟶ sender + receiver + content + address+ language + ontology
content ⟶ String
language ⟶ String | Null
ontology ⟶ String | Null
CFP ⟶ MStructure
inform ⟶ MStructure

Broadcast
CFP Agent sends proposal for selling or bidding proposal **inform** It contains all information related to product

1. Contents of 'Broadcast' by Using FIPA Performatives

Content-1
(CFP
:sender Seller Agent
:receiver Buyer Agent
:content Agent sends a proposal for bidding and exchange of a product
:language ———
:ontology ———
)

Content-2
(INFORM
:sender Seller Agent
:receiver Buyer Agent
:content Agent sends all information of a product for bidding
:language ———
:ontology ———
)

2. Contents of 'Broadcast' Performative

Content-1
(BROADCAST
:sender Seller Agent
:receiver Buyer Agent
:content Agent sends a proposal for bidding of a product with all information and characteristics of a product
:language ———
:ontology ———
)

IV. Application of the Proposed Performatives in E-commerce

In this section, we demonstrate the efficiency of the proposed performatives using a case study of e-commerce. This case study comprises negotiation between the buyer and the seller agents using one scenario but the approach is easily applicable to other scenarios. We have used JADE and created all the agents on localhost for the simulation purpose.

A. Agents' Negotiation for Bidding a Mobile of Buyer Agent

BuyerAgent3 (BA3) wishes to sale its mobile OPPO F7 with bid process. It uses 'Bid performative which consists of 'request', 'inform' and the 'request-when' FIPA performatives. Parameters of 'Bid' are request for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM and its colour is red with a box and accessories. It wants to bid its mobile at the price of 200 $ and sets its goal to get maximum profit. It also communicates to the SellerAgent that when the bid process is done, then it should inform it. SellerAgent uses 'DealNegotaie' performative that is formed of 'agree' and 'inform' FIPA performatives. By using 'DealNegotaie' performative, SellerAgent gives confirmation to the request of BuyerAgnet3 and tells him about the market price of OPPO F7, i.e., 160 $. It gives the time limit for the bid process. The time limit for bid process is 4 days. BuyerAgent3 agrees on the deal of SellerAgent by using 'agree' FIPA performative. SellerAgent sends messages to other buyer agents by using 'Broadcast' performative, which consists of 'cfp' and 'inform'. By using 'Broadcast' performative, SellerAgent informs other buyer agents about the mobile OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories for auction at the price of 180 $ and tells them about the time limit for bid, i.e., 4 days. BuyerAgent1, BuyerAgent5 and BuyerAgent7 accept the proposal by using 'propose'. Remaining agents refuse the request of bid by using 'refuse'. BuyerAgent1 bids the OPPO F7 mobile at the price of 170 $, BuyerAgent5 bids the OPPS F7 at the price of 175 $, BuyerAgent7 bids the mobile at the price of 165 $. SellerAgent informs BuyerAgent3 that BuyerAgent5 bids the OPPO F7 at the highest price, i.e., 175 $ and it asks BuyerAgent3 about the interest in the deal by using 'PermissionNegotiation'. This performative consists of 'inform' and 'query-if'. BuyerAgent3 shows positive response and it enquires about the receipt of the deal for OPPO F7 mobile by using 'PactApprovalNegotiation' performative. This performative consists of 'agree' and 'query-if' performatives. SellerAgent accepts the proposal of BuyerAgent5 because BuyerAgent5 bids the OPPO F7 mobile with the highest price than other bidding agents by using 'accept-proposal'. Table I and Table II below show the process of bidding and the order of exchange of messages using the standardised FIPA performatives and the proposed performatives.

1. E-commerce Application for Bidding a Mobile of Buyer Agent by FIPA Performatives

TABLE I

BIDING A MOBILE OF BUYER AGENT BY USING FIPA PERFORMATIVE

Sr.	Performative (FIPA)	Sender Agent	Receiver Agent	Working
1	Request	BuyerAgent3	SellerAgent	I want to sale my mobile by using bid process
2	Agree	SellerAgent	BuyerAgent3	Yes, I'll sale yours mobile by using bid process
3	Query-if	SellerAgent	BuyerAgent3	Please provide all information of your mobile
4	Inform	BuyerAgent3	SellerAgent	My mobile is OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories
5	Query-if	SellerAgent	BuyerAgent3	Tell me about the maximum biding price of your mobile
6	Inform	BuyerAgent3	SellerAgent	I want to bid my mobile at the price of 200 $
7	Inform	SellerAgent	BuyerAgent3	The market price of OPPO F7 is 160 $ and days for bid is 4
8	Agree	BuyerAgent3	SellerAgent	Ok, I agree on this deal
9	Request-when	BuyerAgent3	SellerAgent	Please inform me when the bid process is complete
10	Cfp	SellerAgent	BuyerAgent1	This is proposal for mobile bid
12	Inform	SellerAgent	BuyerAgent1	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
13	Cfp	SellerAgent	BuyerAgent2	This is proposal for mobile bid
14	Inform	SellerAgent	BuyerAgent2	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
15	Cfp	SellerAgent	BuyerAgent4	This is proposal for mobile bid
16	Inform	SellerAgent	BuyerAgent4	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days.
17	Cfp	SellerAgent	BuyerAgent5	This is proposal for mobile bid
18	Inform	SellerAgent	BuyerAgent5	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
19	Cfp	SellerAgent	BuyerAgent6	This is proposal for mobile bid
20	Inform	SellerAgent	BuyerAgent6	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
21	Cfp	SellerAgent	BuyerAgent7	This is proposal for mobile bid
22	Inform	SellerAgent	BuyerAgent7	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
23	Cfp	SellerAgent	BuyerAgent8	This is proposal for mobile bid
24	Inform	SellerAgent	BuyerAgent8	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
25	Cfp	SellerAgent	BuyerAgent9	This is proposal for mobile bid
26	Inform	SellerAgent	BuyerAgent9	OPPO F7 mobile with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 180 $ and the time limit for bid is 4 days
27	Propose	BuyerAgent1	SellerAgent	I bid this mobile at 170 $
28	Refuse	BuyerAgent2	SellerAgent	I'm not interested
29	Refuse	BuyerAgent4	SellerAgent	I'm not interested
30	Propose	BuyerAgent5	SellerAgent	I bid this mobile at 175 $
31	Refuse	BuyerAgent6	SellerAgent	I'm not interested
32	Propose	BuyerAgent7	SellerAgent	I bid this mobile at 165 $
33	Refuse	BuyerAgent8	SellerAgent	I'm not interested
34	Refuse	BuyerAgent9	SellerAgent	I'm not interested
35	Refuse	SellerAgent	BuyerAgent1	Our deal cannot be done due to minimum price
36	Refuse	SellerAgent	BuyerAgent7	Our deal cannot be done due to minimum price
37	Inform	SellerAgent	BuyerAgent3	Yours bid has done at 175 $ from BuyerAgent5
38	Query-if	SellerAgent	BuyerAgent3	Do you agree on this deal?
39	Agree	BuyerAgent3	SellerAgent	I agree on this deal
40	Query-if	BuyerAgent3	SellerAgent	Please give me the receipt of this deal
41	Accept-proposal	SellerAgent	BuyerAgent3	Your bid 175 $ for OPPO F7 is acceptable

2. E-commerce Application for Biding a Mobile of Buyer Agent by Using E-commerce Performative Based on FIPA Performatives

TABLE II

BIDDING A MOBILE OF BUYER AGENT BY USING THE PROPOSED PERFORMATIVES

Sr.	Performative (FIPA)	Sender Agent	Receiver Agent	Working
1	Bid	BuyerAgent3	Seller Agent	I want to bid my mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
2	DealNegotiate	SellerAgent	BuyerAgent3	Yes, I'll perform bid process for your mobile and the market price of OPPO F7 is 160 $. The time limit for bid process is 4 days
3	Agree	BuyerAgent3	SellerAgent	I agree on this deal
4	Broadcast	SellerAgent	BuyerAgent1	This is a proposal for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
5	Broadcast	SellerAgent	BuyerAgent2	This is a proposal for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
6	Broadcast	SellerAgent	BuyerAgent4	This is a proposal for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
7	Broadcast	SellerAgent	BuyerAgent5	This is a proposal for biding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
8	Broadcast	SellerAgent	BuyerAgent6	This is a proposal for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
9	Broadcast	SellerAgent	BuyerAgent7	This is a proposal for biding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
10	Broadcast	SellerAgent	BuyerAgent8	This is a proposal for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
11	Broadcast	SellerAgent	BuyerAgent9	This is a proposal for bidding a mobile OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only
12	Propose	BuyerAgent1	SellerAgent	I bid this mobile at 170 $
13	Refuse	BuyerAgent2	SellerAgent	I'm not interested
14	Refuse	BuyerAgent4	SellerAgent	I'm not interested
15	Propose	BuyerAgent5	SellerAgent	I bid this mobile at 175 $
16	Refuse	BuyerAgent6	SellerAgent	I'm not interested
17	Propose	BuyerAgent7	SellerAgent	I bid this mobile at 165 $
18	Refuse	BuyerAgent8	SellerAgent	I'm not interested
19	Refuse	BuyerAgent9	SellerAgent	I'm not interested
20	Refuse	SellerAgent	BuyerAgent1	Our deal cannot be done due to minimum price
21	Refuse	SellerAgent	BuyerAgent7	Our deal cannot be done due to minimum price
22	PermissionNegotiation	SellerAgent	BuyerAgent3	Your bid has done at 175 $ from BuyerAgent5. Do you agree on this deal?
23	PactApprovalNegotiation	BuyerAgent3	SellerAgent	Yes, I agree on this deal. Please give me the receipt of the deal
24	Accept-proposal	SellerAgent	BuyerAgent3	Your bid 175 $ for OPPO F7 is acceptable.

Next we present the JADE based communication among the agents using our proposed performatives.

3. Mobile's Bid of Buyer Agent

Bid: BuyerAgent3
(Bid
:sender (agent identifier :name
BuyerAgent3@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content request: "Hello, I want to bid my mobile for sale." inform: The information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM in red colour with a box and full accessories at the price of 200 $. request-when: "Please inform me when bid process is done."
:X-JADE-real-sender rma@localhost:1099/JADE)

DealNegotiate: SellerAgent
(DealNegotiate
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)

:receiver (set (agent identifier :name
BuyerAgent3@localhost:1099/JADE))
:content agree: “Yes, I’ll perform bid process for your mobile. inform: the market price of OPPO F7 is 160$. The time limit for bid process is 4 days.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Agree : SellerAgent
(AGREE: sender (agent identifier: name
BuyerAgent3@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content agree: “Ok, I agree on this deal.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent1@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent2@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red color with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent4@localhost:1099/JADE))
:content cfp: “This is a proposal for biding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent5@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast: sender (agent identifier: name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent6@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent7@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast: SellerAgent
(Broadcast
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent8@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: “Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Broadcast : SellerAgent
(Broadcast: sender (agent identifier: name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent9@localhost:1099/JADE))
:content cfp: “This is a proposal for bidding a mobile. inform: Information of the mobile is OPPO F7 with 3 GB RAM, 128 GB ROM, in red colour with a box and full accessories at the price of 160 $ and the time limit for bid is 4 days only.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Propose: BuyerAgent1
(PROPOSE
:sender (agent identifier :name
BuyerAgent1@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content propose: “I bid this mobile at the price of 170 $”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: BuyerAgent2
(REFUSE
:sender (agent identifier :name
BuyerAgent2@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content refuse: “I’m not interested”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: BuyerAgent4
(REFUSE
:sender (agent identifier :name
BuyerAgent4@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content refuse: “I’m not interested”
:X-JADE-real-sender rma@localhost:1099/JADE)
Propose: BuyerAgent5
(PROPOSE
:sender (agent identifier :name
BuyerAgent5@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content propose: “I bid this mobile at the price of 175$”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: BuyerAgent6
(REFUSE
:sender (agent identifier :name
BuyerAgent6@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE)
:content refuse: “I’m not interested”
:X-JADE-real-sender rma@localhost:1099/JADE)

Propose: BuyerAgent7
(PROPOSE
:sender (agent identifier :name
BuyerAgent7@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content propose: “I bid this mobile at the price of 165 $”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: SellerAgent
(REFUSE: sender (agent identifier: name
BuyerAgent8@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content refuse: “I’m not Interested”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: SellerAgent
(REFUSE
:sender (agent identifier :name
BuyerAgent9@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE))
:content refuse: “I’m not interested.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: SellerAgent
(REFUSE
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent1@localhost:1099/JADE))
:content refuse: “Our deal cannot be done due to the minimum bid price.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Refuse: SellerAgent
(REFUSE
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent7@localhost:1099/JADE))
:content refuse: “Our deal cannot be done due to minimum bid price.”
:X-JADE-real-sender rma@localhost:1099/JADE)

PermissionNegotiation: SellerAgent
(PermissionNegotiation
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent3@localhost:1099/JADE))
:content inform: “BuyerAgent5 bids the OPPO F7 at the high price, i.e., 175 $. query-if: Do you agree on this deal?”
:X-JADE-real-sender rma@localhost:1099/JADE)

PactApprovalNegotiation: BuyerAgent3
(PactApprovalNegotiation
:sender (agent identifier :name
BuyerAgent3@localhost:1099/JADE)
:receiver (set (agent identifier :name
SellerAgent@localhost:1099/JADE)
:content agree: “Yes, I agree on this deal. query-if: Please give me the receipt of the deal.”
:X-JADE-real-sender rma@localhost:1099/JADE)

Accept-Proposal: SellerAgent
(ACCEPT-PROPOSAL
:sender (agent identifier :name
SellerAgent@localhost:1099/JADE)
:receiver (set (agent identifier :name
BuyerAgent5@localhost:1099/JADE))
:content accept-proposal: “Your bid 175 $ for OPPO F7 is acceptable.”
:X-JADE-real-sender rma@localhost:1099/JADE)

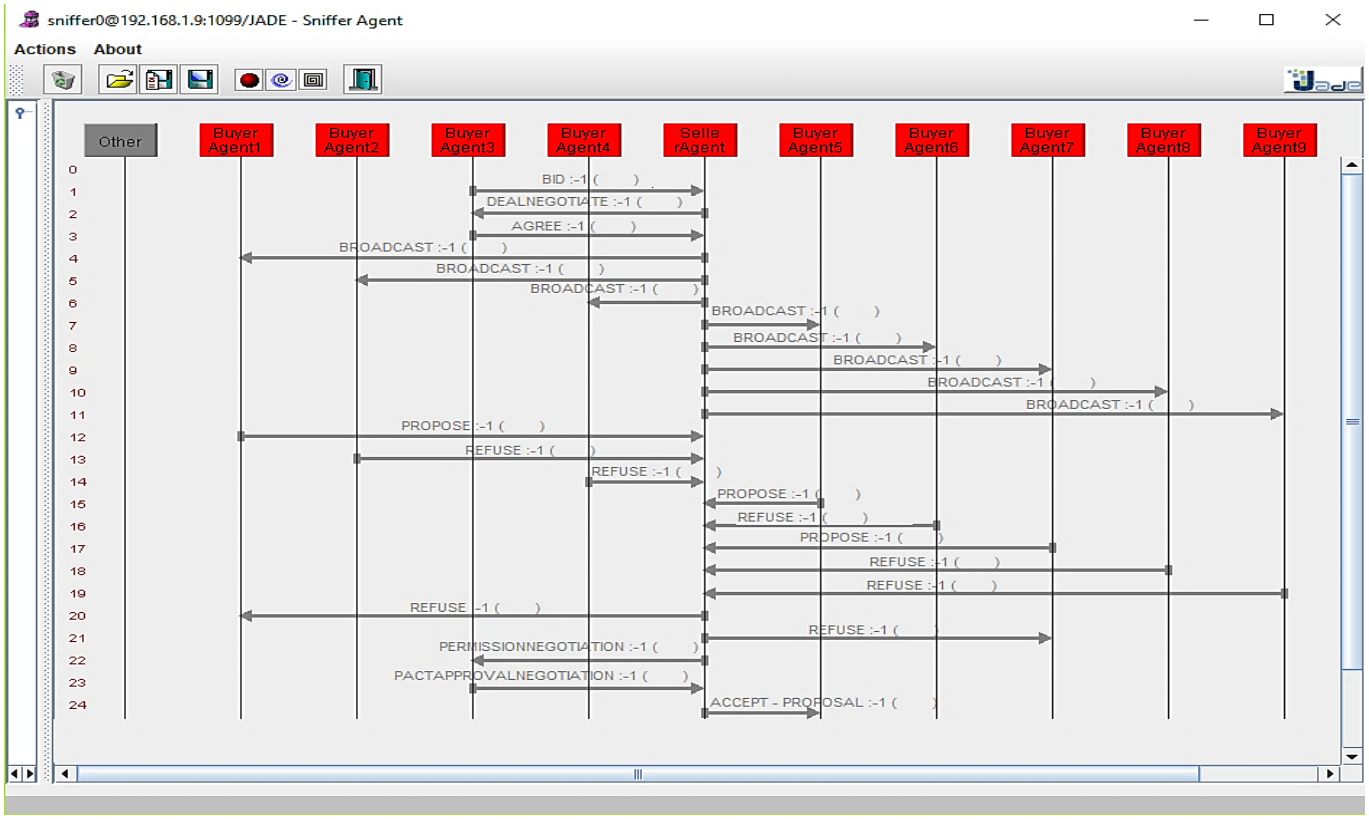

Fig. 1. Bidding a mobile of buyer agent by using e-commerce performative in JADE.

In the given example, by using the standard FIPA performatives, 41 messages are used in the conversation among the agents. If one message is sent in one second, then 41 messages will be sent in 41 seconds. On the contrary, by using our proposed e-commerce performatives only 24 messages are used for the same bidding process among the agents. This amounts to 41 % reduction in total time taken to complete the same bidding process. Additionally, lesser number of messages also decreases the required resources on the platform resulting in the decreased network overhead on the platform.

V. Conclusion and Future Work

In the research, we proposed new performatives for e-commerce domain and defined their precise semantics with the help of BNF. These proposed performatives are directly usable in e-commerce domain and are entirely based on FIPA-ACL. Previously, in case of some intricate situation, such as e-commerce, these performatives were not directly applicable due to a limited number of standardised generic performatives. In such specific domains a situation of misunderstanding may arise among the agents when they use nearly applicable available speech acts. Similarly, a lot of unnecessary messages are communicated over the network when using these generic performatives in any specific domain. However, with our proposed performatives the number of negotiation messages, time consumption and network overhead on the platform are reduced. Additionally, we compared all these newly designed performatives with FIPA-ACL performatives. Subsequently, the new performatives are half in number as compared to the original standardised FIPA-ACL performatives. Furthermore, we successfully conducted our research on the basis of JADE framework to check the functionally of our designed performative using simulation.

For future research, temporal constraints can be integrated into these proposed performatives so that they are readily available to be used in real-time e-commerce, such as online bidding. Additionally, the proposed concept can be used to create new performatives for other specific domains.

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